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Summary

Founder and first director of the Montreal Neurological Institute, Wilder G. Penfield established the "*Montreal Procedure*" for the surgical treatment of epilepsy, a brain disorder characterized by sudden and recurrent seizures. His revolutionary work is the very foundation of neurological studies. He was celebrated as '*the greatest living Canadian.*'

Résumé

Fondateur et premier directeur de l'Institut neurologique de Montréal, Wilder G. Penfield inventa une méthode d'intervention connue sous le nom de « *Protocole de Montréal* » appliqué au traitement chirurgical de l'épilepsie, cette maladie du cerveau caractérisée par des crises récurrentes. Son travail révolutionnaire est considerée comme le fondement des études neurologiques et lui a valu les plus grand honneurs.

Wilder Graves Penfield was born in Spokane (Washington) on January 26th, 1891. He died in Montreal (Quebec) on April 5th, 1976. World-famous brain surgeon, he reflected toward the end of his productive life that "*the only certain virtue*" that came into the world with him at his birth was "*tenacity of purpose*[1]."

In 1899, his father's medical practice failed and he was unable to support the family[2]. His parents separated. His mother took his elder brother and sister and eight-year-old Wilder to live with her parents in Hudson (Wisconsin)[3]. There, he graduated from Galahad School[4]. Following his graduation, he entered Princeton, where he was determined to make himself an all-round scholar, athlete, and leader so that he might qualify for a Cecil Rhodes Scholarship. The best he could do in football in his first year, was to qualify as a substitute on the freshman team. On the advice of Heff Herring, Princeton football player, wrestler and Rhodes Scholar, he went out for wrestling[5], and thereby developed large neck muscles, won the interclass freshman-sophomore wrestling match, and eventually found a place on the varsity football team as a first-string tackle[6].

At the end of his sophomore year, an enthusiasm engendered by Professor Conklin's biology lectures led him to decide on a career in medicine[7]. He obtained a bachelor degree in literature from Princeton in 1913.

Penfield looked forward to beginning his medical education at Oxford (England), but he lost out for the Rhodes Scholarship from New Jersey to an "*excellent fellow*" from Rutgers. Instead, he devoted the year after graduation to earning money for his medical education by coaching the Princeton freshman football team and teaching at the Galahad School. In the middle of the year, he received word that a Rhodes Scholarship for the following year had been awarded him and he was accepted for admission to Merton College at Oxford[8], where he completed a bachelor degree in sciences and, in 1920, a master's degree.

At Oxford, he was influenced by Sir William Osler and Sir Charles Sherrington. Sherrington was noted for his experiments establishing modern understanding of integrated nervous functions[9]. He made Penfield realize that "*the nervous system was the great unexplored field – the undiscovered country in which the mystery of the mind of man might someday be explained*[10]."

In January 1915, he enrolled in courses (histology, pharmacology, bacteriology, and chemistry) that would assist in his completion of a medical degree at Johns Hopkins University (Baltimore, Maryland) which he planned to enter on his return to the United States. He was assisted in arranging this by Sir William Osler, Canadian-born Regius Professor of Medicine. Osler invited Wilder to accompany him on medical consultations from one English hospital to another.

In late 1915, during the Christmas break from his studies at Oxford, Penfield worked briefly as a volunteer in a Red Cross hospital in France. When he returned to the Red Cross work in late March 1916, after the winter term at Oxford, the ship on which he was travelling was torpedoed in the English Channel. Although he was erroneously reported dead and his obituary was published in an American newspaper, he survived the torpedo attack but spent three weeks in a hospital in Dover, and several weeks recuperating at Sir William Osler's residence in Oxford[11].

On his return to America, after two years in England, Penfield was given academic credit for his science studies at Oxford and embarked upon his final years of medical study at Johns Hopkins Medical School[12].

In April 1917, the U.S. began to enter fully into the First World War. The following June, Penfield married Helen Kermott. Several weeks later, he and his wife took a ship to France where they both worked in an American Red Cross hospital in Paris[13].

In late 1917, they returned to the U.S.A. Penfield completed his medical studies at Johns Hopkins and received his medical degree in 1918. The following year, he was surgical intern at the Peter Bent Brigham Hospital in Boston, serving as both apprentice and later assistant to Harvey Cushing, one of the most gifted brain surgeons in the United States[14].

But the memory of the "*undiscovered country*" he had glimpsed through Sherrington's lectures continued to intrigue him. He accordingly returned to Oxford for the third and final year of his Rhodes Scholarship as a graduate student in neurophysiology under Sherrington and following that with a year as a research fellow in clinical neurology and neurosurgery at the National Hospital at Queen Square in London[15].

While in England, he developed a special interest in epilepsy. When this period of his advanced research was finished successfully, Penfield and his family, which by this time included two children, returned to the U.S.

In 1921, he rejected a lucrative position as a surgeon at the Henry Ford Hospital in Detroit – because it would have afforded him no opportunity for research – and accepted instead a post as associate surgeon at Columbia University and Presbyterian Hospital, affiliated with Columbia, and to the New York Neurological Institute[16]. Through his work there, his interest in epilepsy was deepened. In his effort to advance his knowledge and ability in his areas of specialization, Penfield studied first hand the methods used by specialists in Spain[17], Germany and elsewhere. There, he developed his surgical techniques under Allen O. Whipple, and organized and pursued research in a laboratory of neurocytology[18].

His research in 1924 with the Madrid neuro-histologist Pio del Rio-Hortega provided him with metallic staining techniques that yielded new information on the glia[19]. In 1928, he learned from the German surgeon Otfrid Foerster, the method of excising brain scars to relieve focal epilepsy[20].

During his postgraduate years in Oxford and in London, Penfield had turned from experimental neurophysiology toward neurosurgery because he believed that, since the neurosurgeon could lay bare the living human brain, he should be able to study and influence the brain's physiological activity. As he came to realize that he could not carry out an effective approach to knowledge of the brain and make use of that knowledge all by himself [21], he began to dream of organizing an institute where neurologists, neurosurgeons, and neuropathologists would work together in a team, as he had learned as football player and coach[22]. He thought he might be better able to realize this dream in Montreal. He joined the medical faculty of McGill University in 1928 and became, at the same time, neurosurgeon at the Royal Victoria and Montreal General Hospitals[23], convinced by the great Canadian neurosurgeon, Edward Archibald, that his skills were needed there[24]. He moved to Montreal with his best friend William Vernon Cone. At the Royal Vic, he developed a good relationship with Dr. Colin K. Russel, a well-established neurologist who supported him in his surgical treatment of epilepsy. They soon became associates.

Penfield's fascination with the brain led to research into tumours, brain scars and the various forms of epilepsy and he was much in demand as a surgeon. His successes were many but one operation remained in his mind for the rest of his life. A few months after his arrival in Montreal, he was called upon to remove a tumour from the brain of his sister Ruth. After finding that the tumour was malignant and far advanced, he performed a more radical operation most neurosurgeons would never have dared attempt, but could not safely remove all of the malignant cells. Although the operation made it possible for his sister to enjoy a normal life again, the symptoms eventually returned and she died three years later[25].

The difficulties of his sister's case spurred him to make his first effort to realize his dream of an endowed neurological institute for investigation of the brain and mind as a way to human betterment.

After a first rejected application, in 1934 the Rockefeller Foundation joined with the Province of Quebec, the City of Montreal, and private donors to help implement Penfield and Cone's Montreal Neurological Institute. That application resulted in a grant of $1,232,000[26].

The Institute gradually emerged as a centre of outstanding research, teaching and treatment. Like Osler, Penfield worked with great skill as he constantly sought to find new means to cure epilepsy and related dysfunctions. Penfield led the commitment, dedication, and hard work of the institute. He was its director during 25 years, until 1960[27].

In drawing together the disciplines of neurosurgery, neuropathology, neurology and related basic sciences, Penfield transformed the study of the brain.

One of his associates was psychologist Donald Olding Hebb from Halifax. In the 1930's, the brain was regarded as a relay station to process incoming and outgoing impulses; behaviour was just stimulus and response. Hebb worked with Wilder Penfield from 1937 to 1939 and noted that loss of large parts of the brain did not necessarily diminish intelligence. He was convinced that neural circuits linking incoming and outgoing neurons were the loci for thought and emotions[28]. In 1949, Hebb published *The Organization of Behavior*, which revolutionized psychology by putting "*mind*" back into the brain.

Penfield believed that the problem of neurology is to understand man himself. He made important gains in the study and treatment of the brain. In particular, he investigated the surgical treatment of epilepsy – especially focal epilepsy –, then considered to be an incurable disease.

His surgical studies yielded reports on brain tumours, the pial circulation, the mechanisms of headache, the localization of motor, sensory and speech functions, and the role of the hippocampus in memory.

Penfield's primary concern was that his patients avoid unpleasant secondary effects such as memory loss or language disorders which frequently followed the removal of the brain tissues causing the epileptic seizures[29]. He stimulated the cortex by a mild electric shock in order to locate the different brain functions, like language and memory, and determined which part of that organ should be removed without any danger of neurological deficit. Among his many discoveries was that he could summon a patient's past experiences by mildly shocking the temporal lobes and stimulating memory. As he carefully probed the brain, he found that administration of a mild electric shock to one of the temporal lobes could cause the patient to recall precise personal experiences that had long been forgotten. He also discovered that stimulating parts of the cortex could evoke vivid and specific memories[30] including sounds and smells. Epilepsy arising in the temporal lobe of the brain assumed special importance because of the re-excitation of past experiences that occurred when the cortex was stimulated during surgery. It was an area that Penfield was passionate about, discovering and unlocking the hidden treasures in the human mind[31].

While he was developing a surgical approach to the treatment of epilepsy, Penfield began to map the brain and determine which functions of the body were controlled by which brain segment. He located the accumulated store of memory of past events and the emotions, sensations, and thoughts to which the events had given rise.

Penfield developed a new surgical approach that became known as the "*Montreal Procedure*". He developed his method while his patients were awake and able to interact with him. Using local anaesthetics, he removed the skull cap to expose the brain tissue of the conscious patient. When he probed certain areas of the brain, the patients would be able to provide him feedback on what they were experiencing at that very moment[32]. Then, he was able to map the functions of tissues in different parts of the brain – a dream already made, but in vain, by Gall and Spurzheim in their treatise on the *Anatomy and Physiology of the Nervous System* (1810)[33]. In most cases, he identified the precise location of the source of the seizure activity. He could then remove or destroy that bit of tissue to end the patient's seizures.

Furthermore, Penfield completed his mapping of the brain. He discovered the sources of memory and dreams. Some of the modern theories of the separate functions of the two cerebral hemispheres were built upon his findings. His concept of centrencephalic seizures[34] arising from deep midline portions of the brain had an important impact on the understanding of the relationship between the brain's structures and consciousness[35] – Fritsch and Hitzig (1870) being "*the first to demonstrate that supraliminal electrical stimulation of the motor cortex with galvanic currents results in the development of a convulsive seizure which continues far longer than the duration of the stimulus*[36]."

Perhaps what made this gentleman even more amazing was the humanity with which he approached his patients and their families: "*The patient must understand the gravity of his condition, and must be informed accurately of the chances of success*[37]." He made a point of getting to know them as individuals, building a high degree of confidence in his knowledge and skills: "*Fools, alas, and charlatans, too, have traded on the credulity of the epileptic in his great need. (...) The physician who unwittingly administers anticonvulsant remedies to a patient with benign tumor of the brain is open to equal criticism with the surgeon who carries out a craniotomy on a patient without a reasoned therapeutic plan. Adequate investigation of his case is the right of every epileptic who seeks help*[38]."

In treating 1,132 patients during Penfield's directorship, the Institute improved the techniques of brain surgery and added materially to neurological knowledge. Research at the Montreal Neurological Institute has led to improved surgical and nursing techniques for the management of spinal lesions, to the development of electroencephalography (EEG) to treat conditions such as epilepsy, and to a deeper understanding of cognitive and other behavioural changes associated with brain lesions. Non-invasive imaging techniques, such as computerized axial tomography (CAT) and positron emission tomography (PET), in conjunction with a new understanding of neurotransmitters, help researchers understand the way the various parts of the brain and nervous system grow, develop, take on specific tasks, and repair and replenish themselves.

Penfield's work brought him many high honours. He was the first recipient, in 1967, of the $50,000 Royal Bank Centennial Award for Canadian Achievement. President of the Royal College of Physicians and Surgeons of Canada and of the American Neurological Association, Penfield was a fellow of the Royal Society of London and twenty-five other scientific and professional organizations and a recipient of honorary degrees from as many universities: Princeton, Oxford, McGill, Montreal... Twice decorated by Canada, he was also awarded the United States Medal of Freedom, crosses of the French Legion of Honour and the Greek Legion of George I, and the British Order of Merit.

Penfield received the Lannelongue Medal of France in 1958, and the Lister Medal of the Royal College of Surgeons in 1961. His many scientific writings – among them *The Cerebral Cortex of Man*, co-authored with Theodore Rasmussen, were accepted as definitive statements in their field.

He retired from the McGill medical faculty in 1954. That same year, he co-authored with Herbert Jasper *Epilepsy and the Functional Anatomy of the Brain.* He visited Princeton in 1956 to deliver the Vanuxem Lectures, later published and co-authored by Wilder Penfield and Lamar Roberts, as *Speech and Brain-Mechanisms*. He also completely rewrote his late mother's novel, *Story of Sarah* (based on a Biblical tale), which was published under the title *No Other Gods*.

In 1960, he intensified work on his second career in line with his belief that "*rest, with nothing else, results in rust*[39]."

He then published *The Torch,* a biographical novel about Hippocrates. Three years later, he brought out *The Second Career,* a collection of essays and addresses encouraging others to use retirement for the development of a new career.

He became first president of the Vanier Institute of the Family. In 1967, his participation in the Josiah Wood Lectures resulted in the publication of *Man and His Family,* a collection of personal reflections on the family. That same year, he produced *The Difficult Art of Giving,* a biography of Alan Gregg, director of the medical sciences division of the Rockefeller Foundation, who had engineered the grant that had made the Montreal Neurological Institute possible.

Penfield was widely known for promoting early second-language training[40]. In 1959, Penfield observed that complete recovery of language ability after brain damage was possible in children but not in adults. For Penfield, there is a limited age – 10 years – beyond which acquiring a second language becomes very difficult. After 10, the brain gradually hardens. He advocated that "*the child who hears a second language very early has a great advantage in many aspects of education and life*[41]."

Penfield's writings on the relationship between science and religion reflected his insight as a renowned scientist and dedicated humanism. Emulating Osler in *The Second Career* and *Second Thoughts,* he reflects on the need for "*eternal vigilance and resolute action*" in a changing world[42].

In 1974, he completed *The Mystery of the Mind,* an account for laymen on brain research. There, he set out his views on the relationship between the human brain and the human mind.

Three weeks before his death, Penfield completed the draft of his autobiography, *No Man Alone,* a phrase repeated frequently in the book to underline his emphasis on the team approach to neurological research and treatment. Published posthumously in 1977, this final work covers the period from 1891 to 1934. In 1981, Jefferson Lewis wrote *Something Hidden. A Biography of Wilder Penfield.*

Penfield depicted himself as follows: "*I am an explorer, but unlike my predecessors who used compasses and canoes to discover unknown lands, I used a scalpel and a small electrode to explore and map the human brain. Throughout my career, I was driven by the central question that has obsessed both scientists and philosophers for hundreds of*

years. Are mind and body one? Can the mind – thinking, reasoning, imagination – be explained by the functions of the brain? As a doctor, my first concern was always for my patients – to relieve the terrible suffering caused by diseases such as epilepsy. I found that by stimulating the exposed brain of a conscious patient with a small electrical current, the patient could tell me what they were feeling or seeing, and through this we could isolate the damaged part of the brain. I developed treatments for epilepsy based on this knowledge. But the procedure also opened a window to the mind, giving us for the first time a glimpse of how dreaming occurs, how memory works, and where speech and speech comprehension reside[43]."

We will remember Wilder G. Penfield for his humanity and his vigorous scientific approach to unveiling the mysteries of the human mind.

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27 Jefferson Lewis, *op. cit.,* p. 258.
28 Donald O. Hebb, "*Intelligence in Man after Large Removals of Cerebral Tissue,*" p. 86. See also: Donald O. Hebb and Wilder Penfield, "*Human Behaviour after Extensive Bilateral Removal from the Frontal Lobes,*" p. 425.
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31 Jefferson Lewis, *op. cit.,* p. 201.
32 Wilder Penfield, *The Mystery of the Mind,* p. 21.
33 Wilder Penfield and Theodore Rasmussen, *op. cit.,* p. 1.
34 Wilder Penfield and Herbert Jasper, *op. cit.,* p. 27-28. See also: Wilder Penfield, *The Mystery of the Mind,* p. 16.
35 "*Consciousness*" must be understood in terms of an electrical activity of the brain, instead of psychological or

Freudian terms – even Freud's contribution to the understanding of mind began with his "*limited energy model*". Charles Hampden-Turner, *Maps of the Mind*, p. 40. See also: Wilder Penfield and Herbert Jasper, *op. cit.*, p. 196.

36 Wilder Penfield and Herbert Jasper, *op. cit.*, p. 183.

37 *Ibid.*, p. 748.

38 *Ibid.*, p. 747. See also: Jefferson Lewis, *op. cit.*, p. 246.

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43 Quoted from Canada Science and Technology Museum's Web site: www.sciencetech.technomuses.ca/english/about/hallfame/u_i11_e.cfm

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